Lee Kuan Yew School of Public Policy
National University of Singapore

469C Bukit Timah Road
Oei Tiong Ham Building
Singapore 259772
Tel: (65) 6516 6134 Fax: (65) 6778 1020
Website: www.lkyspp.nus.edu.sg

Lee Kuan Yew School of Public Policy

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Dealing with the Likelihood of Failure over the Long-Term: Adaptive Policy Design under Uncertainty

Sreeja Nair
Lee Kuan Yew School of Public Policy
National University of Singapore
Singapore
Email: sreeja.nair01@nus.edu.sg

and

Michael Howlett
Department of Political Science
Simon Fraser University
Canada
And
Lee Kuan Yew School of Public Policy
National University of Singapore
Singapore
Email: Howlett@sfu.ca

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Theme 3: Anticipating and Overcoming Failures

Abstract

Policy failures are in a sense inevitable. That is, if a policy developed to deal with a specific problem or issue is left in place long enough it is highly likely that over time the environment or problem context will shift enough that the policy will become obsolete or irrelevant and like a hulk adrift on the ocean, may do more harm than good simply being left in place. This phenomenon of a necessary linkage between a policy and its context and the need for content to be continually updated to deal with changes in context has been noted in recent work by Baumgartner and Jones and Lejano and Shankar, among others. However these works have not distinguished between types of policy contexts and the extent of the need for updating or, to put it another way, the extent to which it is likely that a policy will become obsolete and the according need to design a policy to be adaptive right at the outset of policy creation. This paper addresses this issue, examining the concepts of ambiguity and 'deep uncertainty' developed by Walker and his colleagues and applying these to considerations of policy failure and the means to overcome them.

Introduction: The Inevitability of Policy Failure Over Time

As Callander (2011) has noted, at the best of times "policy making is hard". That is, even in the best of circumstances policy-makers have imperfect knowledge and are faced with many constraints in the efforts to craft government actions to address real or imagined problems and issues. Moreover, in most governmental systems they also face almost certain punishment for their failures of both omission and commission yet earn few lasting benefits or entitlements from achieving the success expected of them (Howlett 2012). As a result it should not be surprising that they often react in a very conservative or status quo fashion when faced with new challenges (Howlett 2014).

However it is also the case that governments cannot hide from problems forever and that in some specific circumstances, such as electoral campaigns or career-building efforts, do favor action over inaction and 'positive' action over 'negative' problem denial or attacks on their detractors and problem formulators (Howlett 2014; Saward 1992). In such circumstances, as Hood (2002; 2010) and others have noted, it is important that policy-makers correctly evaluate the risks of failure. This is both in order to avoid blame in the future which might rebound upon them if they claimed credit for resolving an issue in the present (Twight 1991) but also, and more importantly in many circumstances, in order to

ensure that a policy deals with an issue effectively not just in the short-term but also the long run (Jacobs 2008).

This long-term orientation and dimension of political success and failure is an element of policy-making which has been largely ignored or explained away as irrelevant, with many observers citing the short-term horizons attributed to policy-makers, especially the electoral ones attributed to political ones (Ullen 1990; Warwick 2000) as powerful enough to overcome any long-term orientation they might desire. However many policy-makers are not politicians – such as administrators and managers – and are concerned about long-term reputations or the public good rather than electoral advantage. Against the assumption of short-term influences promoted in the media and by pundits around the globe, as Jacobs (2011) noted, long-term policy making is in fact the norm in many areas ranging from social security and pension policy to natural resource and environmental management. Such behaviour reveals a pattern of risk management activity much different from those enamored of explanations which focus only upon short term electoral dynamics (see also Majone 2010; Reimer 2010).

Designing for the long term, however, is a vexing problem for policy designers since, over time, it is likely that any policy simply left in place will fail. That is, *ceteris paribus*, if a policy developed to deal with a specific problem or issue is left in place long enough it is highly likely that over time its environment or problem context will shift enough that the policy will become obsolete or irrelevant and like a hulk adrift on the ocean, may do more harm than good simply being left in place. This phenomenon of a necessary linkage between a policy and its context and the need for content to be continually updated to deal with changes in context has been noted in recent work by Baumgartner and Jones (Jones and Baumgartner 2012) and Lejano and Shankar (2012), among others. However these works have not distinguished between types of policy contexts and the extent of the need for

updating or, to put it another way, the extent to which it is likely that a policy will become obsolete and the according need to design a policy to be adaptive right at the outset of policy creation.

This paper addresses this issue, examining the concepts of ambiguity and 'deep uncertainty' developed by Walker and his colleagues (Walker et al 2012) and applying this to considerations of policy failure and the means to overcome them. In this view, policies must be designed with their problem contexts in mind and those that are unable to function effectively under dynamic and uncertain conditions are often unable to achieve their intended goals and can also impede the ability of societies to adapt to the changing conditions (Swanson and Bhadwal, 2009).

A critical challenge that policy-makers face in all situations is responding to a problem under conditions of uncertainty (Simon 1991; Morgan and Henrion 1990; Swanson et al, 2010). Given this uncertainty there is a need to identify policy responses to help policies effectively 'adapt' to match the rate and level of projected change in their environments. Decision making under a high degree of uncertainty hence should result in polices flexible enough to accommodate conditions of change and robust enough to withstand multiple scenarios in the future, in order to enable decisions to withstand long-term change (WRR, 2011).

Dealing with the Inevitability of Failure: Considerations of Ambiguity and Uncertainty

But not all environments change as rapidly as others and not all uncertainties demand the same response. Failing to correctly identify the bounds and range of these uncertainties is a major cause of policy over and under-reaction (Maor 2012a and 2012b) - or over and under-design - and these elements of the risk environment must be correctly understood and diagnosed by policy-makers in specific circumstances if policy failures are to be avoided through improved or more accurate policy design.

Contrasting Epistemic and Ontological Uncertainty: The Need for Better Classifications

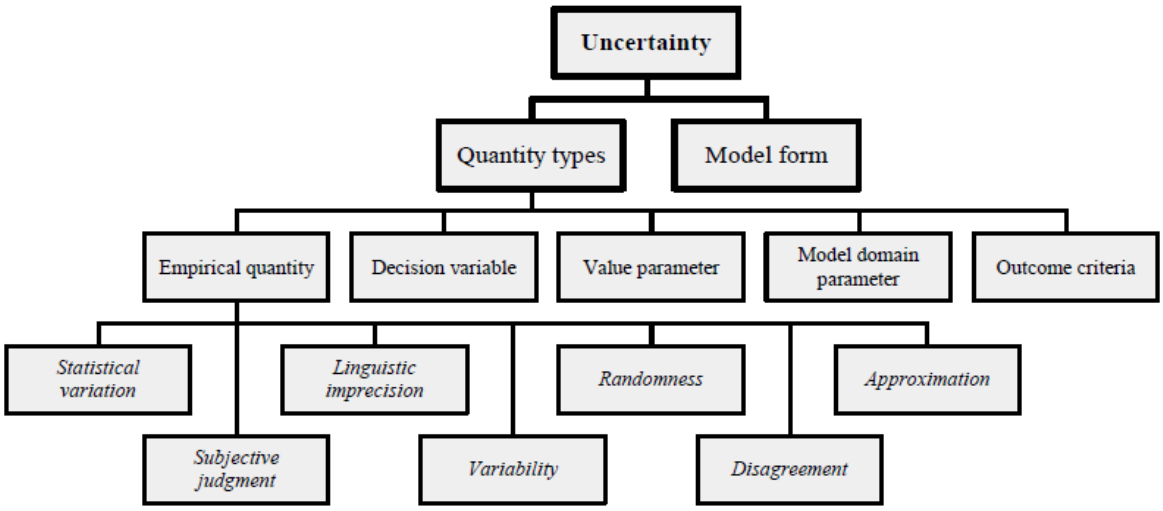
The concept of uncertainty has been widely interpreted and studied in diverse disciplines that influence public policy including the physical sciences, social sciences, mathematical sciences, engineering, economics, philosophy and psychology (Walker et al, 2012). Dealing with long-term policy-making and its design, however, requires a better classification of the different types of uncertainty policy-makers and policies face than is provided in most of these fields.

Simply classifying uncertainty as that aspect of knowledge whose probability is unknown, for example, makes it difficult to proceed with 'real-world decision-making' (Morgan and Henrion 1990). A key distinction drawn in the economics and finance literature – which derives from the work of Knight (1921) – is useful in moving beyond this simple idea. This involves distinguishing between the uncertain future in which uncertainty is represented by known probability distributions ("Knightian risk") and that in which distributions themselves are unknown ("Knightian uncertainty"). In their well-known volume on uncertainty and policy-making, Morgan and Henrion (1990) develop this insight and difference in presenting an uncertainty classification for quantitative policy and risk analysis models based on whether the uncertainties arise from the empirical quantities and variables used in these models or are inherent in the form and structure of these models.

As they note, uncertainty in parameter estimates of models can arise from many sources. These include such origins as statistical variation owing to random measurement errors, "linguistic imprecision" in the case of quantities that are not well-specified and are different to be empirically measured, variations over time and space, randomness, subjective judgment, marking the difference between the true and expected value of the quantity, disagreement between experts, and/or differences between the real and approximated value of a quantity of goods or services over time.[1] Uncertainties which extend beyond the model

parameter variability, however, represent a further distinct genus of uncertainty which is more profound and much harder to deal with (see Figure 1). Uncertainty can thus be knowledge–related (epistemic) due to incomplete information availability on system parameters; related to inherent variability and unpredictability of the system itself (physical system, human behavior, technological advancement, "surprise" etc.) (Walker et al, 2003); or ontological i.e. due to the "simultaneous presence of multiple frames of reference about a system among different actors" (Kwakkel et al, 2010).

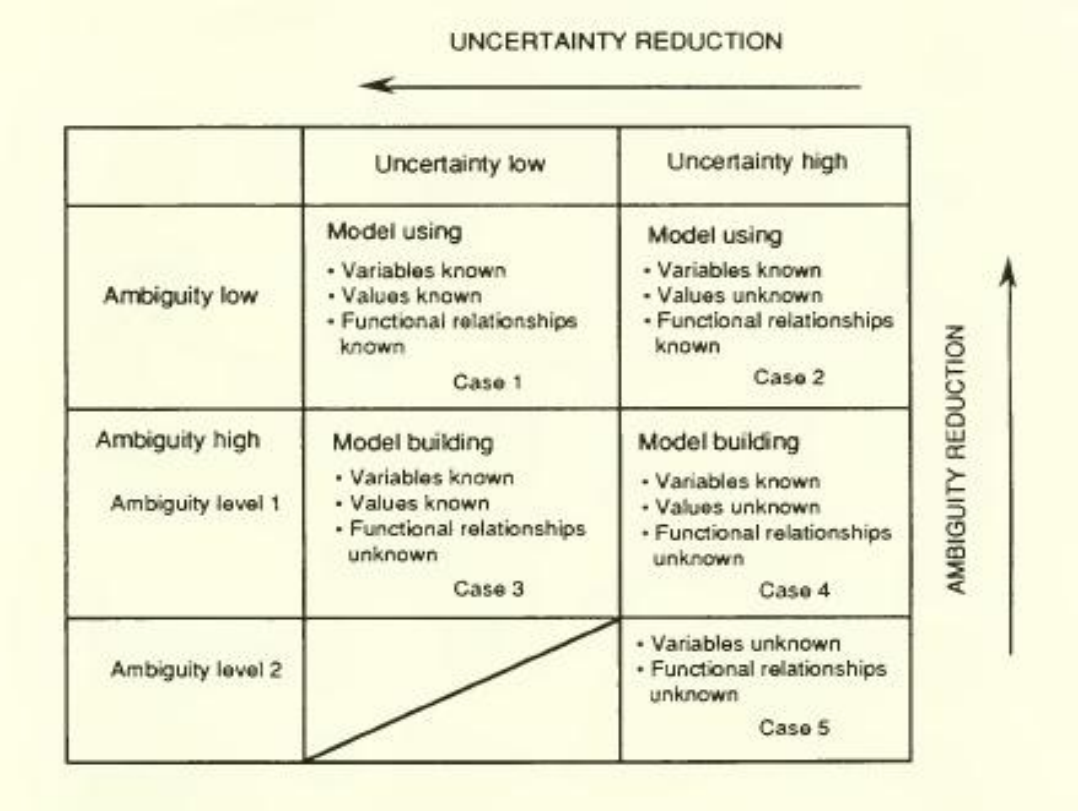
Figure 1: Uncertainty classification for policy and risk analysis (Morgan and Henrion, 1990)



The distinction between epistemic uncertainty arising due to incomplete, inadequate or complete lack of information on one hand and ontological uncertainty has been brought out more evidently in classifications which followed Morgan and Henrion's. Schrader et al (1993), for example, differentiates "uncertainty", or a lack of information on the variables of interest from "ambiguity", a state in which there is a 'lack of clarity' on the variables themselves and their functional relationships (see Figure 2).

Although sometimes elided, (epistemic) uncertainty and (ontological) ambiguity are two very different concepts which should not be confused or improperly juxtaposed.[2]

Figure 2: The Uncertainty- Ambiguity Matrix (Schrader et al, 1993)



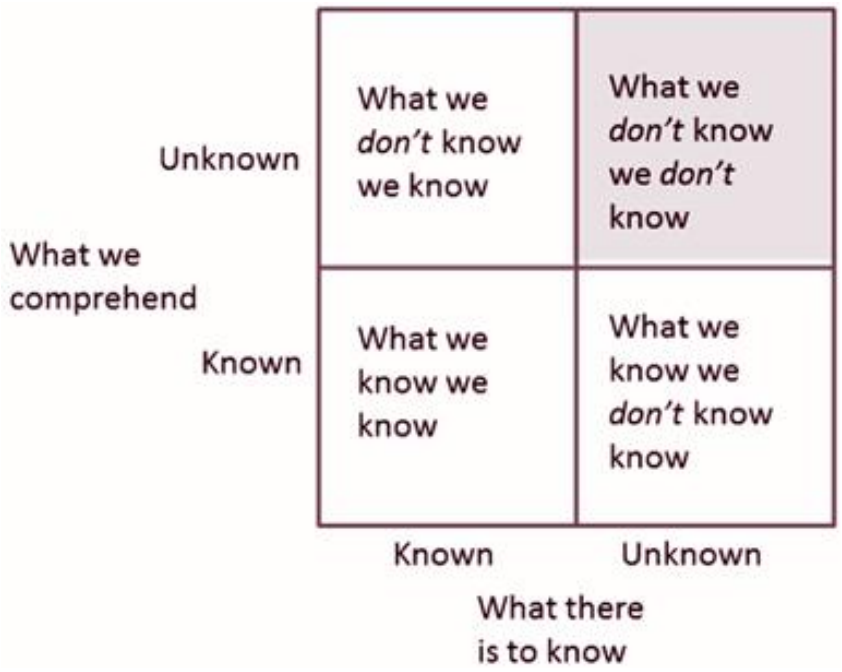
Brugnach et al (2008) have continued to develop this 'ambiguity-uncertainty' distinction. They present ambiguity as a relation that involves an object(s) of perception or knowledge which various actors share about the nature of future states of being (ontological). They consider this kind of ambiguity as uncertainty of 'a third kind' apart from the first type of uncertainty inherent in a system (systemic risk) and the second arising due to lack of knowledge (epistemic risk).[3]

The Notion of Deep Uncertainty and Its Policy Consequences

The more recent uncertainty classifications developed by scholars such as Walker et al (2003), Kwakkel et al (2010) and Walker et al (2010) utilize these insights into the differences between different types of uncertainty to develop a theory of policy design for dealing with ambiguity or "deep uncertainty" over the long-term.

Like Morgan and Henrion these authors focus on both epistemic and ontological uncertainty in policy decisions and classify these policy contexts according to the location and level of uncertainty they involve. Here they distinguish between the 'location' of uncertainty; that is, where uncertainty occurs, including at the boundaries of the system, in the conceptual policy model or a computer-based model, in model implementation, or with input and output data. More significant, however, is their notion of "levels of uncertainty" which they argue range from that of complete determinism about the system being studied when all possible knowledge is comprehended (all "known-knowns") to total ignorance (all "unknown unknowns") (Walker et al, 2010; Becker and Brownsen 1964) (see Figure 3).

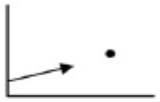
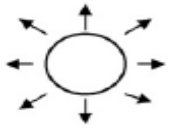
Figure 3 – Knowledge and Comprehension Matrix



On this spectrum Walker et al (2010) include Level 1 (shallow) uncertainty – where multiple alternative states representing the system with specific probabilities are present; Level 2 (medium) uncertainty – where multiple alternatives can be ranked based on 'perceived likelihood' of their occurrence are present; Level 3 (deep) uncertainty- where multiple alternatives are present but these cannot be ranked in terms of their likelihood of occurrence;

and Level 4 complete ignorance – where there is the inability to present any realistic alternatives (see Figure 4).

Figure 4: Levels of uncertainty (Walker et al, 2010)

Determinism		Level 1	Level 2	Level 3	Level 4	Total ignorance
				Deep Uncertainty		
	Context	A clear enough future 	Alternate futures (with probabilities) 	A multiplicity of plausible futures 	Unknown future 	
	System model	A single system model	A single system model with a probabilistic parameterization	Several system models, with different structures	Unknown system model; know we don't know	
	System outcomes	A point estimate and confidence interval for each outcome	Several sets of point estimates and confidence intervals for the outcomes, with a probability attached to each set	A known range of outcomes	Unknown outcomes; know we don't know	
	Weights on outcomes	A single estimate of the weights	Several sets of weights, with a probability attached to each set	A known range of weights	Unknown weights; know we don't know	

One of the other of these scenarios will characterizes the problem environment of a policy and a common source of failure is the mischaracterization of uncertainty and especially the mistake of failing to appreciate the difference between uncertainty and ambiguity in policy design efforts.

The Policy Relevance of Uncertainty

Different policy problem environments correspond to these different levels of uncertainty and their propensity to fail over time and their appropriate policy treatment vary accordingly. Policy problems characterized Level I uncertainty, for example, are at least in theory not very difficult problems at all and ones very likely to be resolved by standard treatments. Hence, for example, controlling a housing market though interest (mortgage) rate

manipulation is a well known treatment for either encouraging or discouraging building and offers only a very limited range or space for failure – such as not setting the interest rate level high (or low) enough. Level II uncertainty is only slightly more complex and may have some unexpected results – such as when tobacco price hikes run into problems with smuggling and black markets – which are more difficult to predict and control but are neither completely unexpected nor surprising when they occur.

Level III problems featuring deep uncertainty however, are much more complex as the ratio of ambiguity to uncertainty is much higher. In these cases, such as when transport planners try to increase the number of walkers and cyclist at the expense of car drivers, the number of possible tools and scenarios climbs dramatically and thus, ceteris paribus, so do the chances of failure of any single initiative of policy package or set of measures (Taeihagh et al 2013). Conventional forecasting methods such as Monte Carlo simulations and quantitative methods using statistical analyses are not adequately equipped to deal with situations of 'deep uncertainty' (Walker et al 2010, Brugnach et al 2008). In these cases there is little agreement on the choice of models to characterize a system's variables and their interactions and assign likely probability distributions (McInerney et al 2011), and/or value diverse possible future outcomes (Walker et al 2010).[4]

Finally there are Level IV problems in which the level of both known unknowns and unknown unknowns is much higher and effective decision-making almost if not wholly impossible. Climate change is one such problem with multiple perspectives regarding the issue as well as potential solutions. Uncertainty in climate assessments can emerge owing to lack of data or lack of agreement on results, statistical methods, error of measurement, use of approximations, subjectivity in judgment, uncertainty in human behavior, errors in model structure, errors in values of parameters, likelihood of change in parameters from historical values, differences in concepts and terminology, choice of spatial/ temporal units,

assumptions taken etc. Additionally, climate change is a global phenomenon with local impacts, and there is a time delay when these impacts are manifested.

Policy Failure under Uncertainty: The Need for Adaptive Policies

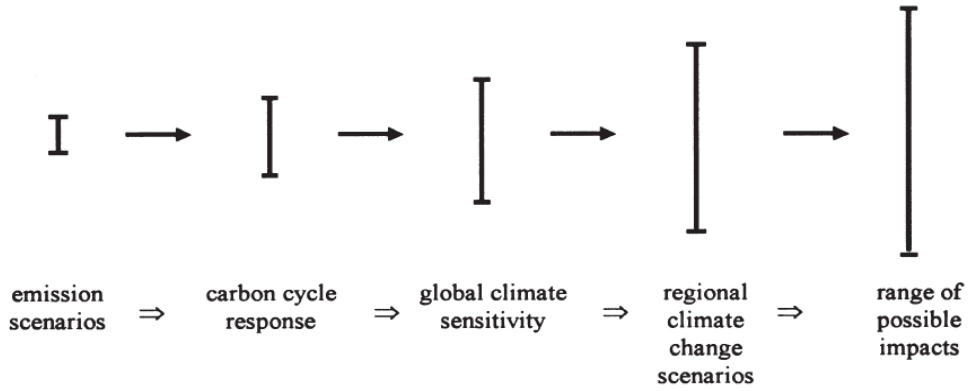
Day and Klein (1989) suggest that most government policies are crafted in response to events that are 'reasonably predictable.' Most of the research in the engineering, social, and natural sciences has assumed that uncertainties emerge owing to a lack of information or random variability, thus triggering the quest for information generation and processing, and heavy reliance on stochastic methods and statistical analysis. But with rising degrees of uncertainty, even with this effort the level of knowledge about the future states of a policy environment decreases and this can alter the suitability of policy solutions to address specific policy problems.

Ambiguity and 'deep uncertainty' are central features of many significant policy issues and policy-makers engage with such issues at their peril (Howlett 2014). A faulty policy design owing to an incorrect appreciation of the degree or level of uncertainty characteristic of a problem can further impede the effective functioning of policies and realization of intended policy goals and objectives (Swanson and Bhadwal, 2009).[5] Thus, even policy solutions designed in response to a 'most likely future' scenario or a limited range of plausible futures ("robust policies") can result in policy failure if the degree of uncertainty involved in them is misdiagnosed (Walker et al, 2013; Hallegatte et al 2012).

Even an assumption of 'no-harm' or 'no-regret' nature of certain policy choices in the short-term can mask their adverse (sometimes irreversible) effects in the long-run and thus delay timely preventive action. This is because in such issue areas, uncertainty can gather and often be magnified through a "cascade of uncertainty" or an uncertainty explosion" (Schneider and Kuntz-Duriseti, 2002, see Figure 5), which refers to the process whereby uncertainty gradually accumulates in the course of developing future projections of a

phenomenon and its possible impacts. The cascade also implies that in a causal chain the characteristics of the aggregate distribution of outcomes might be very different over time.

Figure 5: Uncertainty explosion in climate change studies (Schneider and Kuntz-Duriseti, 2002)



In such contexts policy events will often appear to be unpredictable, 'unforeseen' and 'unprojectable'; catastrophic; or ones where interpretation of uncertainty signals is convoluted because of associated moral and social issues. Unexpected events or 'wild-cards' (Wardekker et al 2010) that can impact policymaking with significant social and political implications will be more frequent. And a significant challenge for policymakers in such cases is that such events offer little or no scope for the decision-maker to respond from history or experience (Walker et al 2010, Lempert et al 2003), although they may often be able to respond by analogy (Hood 1986).

Taking the specific example of climate change, Smith et al 2010 argue that current decision-making on adapting to the impacts of climate change focuses on 'adjustments' to current activities and the possibility of a potential transformation in social and political regimes largely remains unaddressed (Pelling 2010, Smith et al. 2010). While much of the effort towards reduction of uncertainty has focused on gathering more information and

addressing gaps in knowledge, this step by itself has found to be inadequate in ensuring the development of a 'good' policy design under uncertainty.

While such issues might have once been termed a 'wicked problem' (Rittel and Weber, 1973) in the sense that both the problem cause and solution are unknown, they are much more serious than that. Levin et al (2012), for example, argue that climate change is in fact in a special class of 'super-wicked problems' because as any action towards addressing climate change delays, the problem gets further difficult to solve; secondly, those responsible for causing the problem and who possess the means to solve it, lack any clear incentive to do so in practice; and thirdly, because a legal institutional framework to address the spatial and temporal dimensions of this issue is lacking. Many of the current climate plans and policies are not designed to undertake transformative changes in the future and therefore are unlikely to be able to adequately deal with the high levels of uncertainty and ambiguity which are a feature of this problem context. In such circumstances policy-makers may opt to do little if anything and such inaction may cause a failure cascade which will be much more difficult to correct in the future (Howlett 2014).

This is not necessarily a completely bleak prognosis for a future composed of continual large-scale policy failure, however. Rather it should be highlighted that, over time, most of the serious planning problems posed by deep uncertainties at present may be reduced. That is, as the future approaches, by definition, it becomes more like the present and hence better known. And a strategy of policy design focused on adaptation over time is well suited to dealing with Level III and Level IV uncertainty.

Crafting Adaptive Policies

The concept of being prepared to deal with 'surprise' or unexpected changes has largely been used in the ecological context (Lindenmayer et al. 2010) but also applies to policy-making. The European Environment Agency (2001) report on long-term policies, for

example, repeatedly emphasized the importance of building into policies various processes to recognize early warnings of changes in policy environments, especially as new knowledge emerges.

The focus of policy design under uncertainty has typically been one geared to dealing with uncertainty but not ambiguity: to reduce uncertainty where possible, or in other cases, assess the range of uncertainty and then identify policy measures that are expected to be 'robust' within this range (Bredenhoff-Bijlsma, R., 2010). Policies need to be 'adaptive' (adapt to changes over time), however, if they are to 'sustain', that is, survive under conditions of change in which the environment in which the policies are deployed and operate is of a Level III or IV type (Walker et al, 2013). The concept of "*adaptive policymaking"* has received much attention in the last decade as a useful approach to dealing with very high levels of uncertainty and ambiguity,

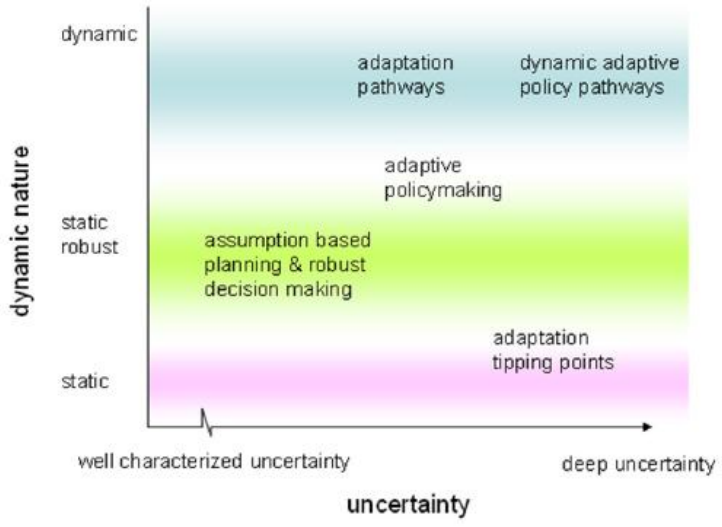
Hallegatte et al (2012), for example, have argued in the case of climate change policy that it is difficult to define a "best solution" given climate change uncertainties, and instead suggest that "a menu of methodologies" is needed, together with some indications on which strategies are most appropriate in which contexts. While maintaining the status quo is an option, lack of action may eventually prove fatal in this cases. Augusdinata (2008), in a more comprehensive analysis, has argued that in general five possible policy responses are available to governments dealing with long-term uncertainties. These include doing nothing – that is, enacting no new policy until the impending uncertainty is resolved; instituting a delaying policy – that is, maintaining the status quo while efforts are made to reduce or better characterize uncertainty by gaining more knowledge; attempting an 'optimal' policy approach – that is, using 'best estimate' or best guess models to choose an 'optimal' policy; adopting a static robust policy approach – that is, adopting a policy that performs 'reasonably well' across most likely plausible future scenarios; or taking an adaptive policy approach –

that is, involving plans right from the outset to adapt the policy over time as conditions change and learning takes place.

Similar to Augusdinata (2008), Walker et al (2013) have highlighted four ways (overlapping to some extent) in which policies and plans can address different levels of uncertainty. These include planning for the worst case scenario - which is likely to be expensive and not adequately equipped to deal with 'surprise'; aiming at resilience – that is, a policy which accepts the likelihood of an adverse future but focuses on quick recovery (Chandler, 2014); again, aiming at static robustness that targets at reduction of adverse impacts across a range of possible range of conditions or adopting a model of dynamic robustness that allows policy/plan to change over time as the conditions change and new knowledge emerges.

A later version of this typology is set out Figure 6 below.[6]

Figure 6: Approaches for developing adaptive policies (Walker et al, 2013)



Adopting any of the strategies outside of 'dynamic robustness' or 'adaptive policy-making" in a context of high uncertainty is likely to result in policy failure. Policies that are

rigid or less flexible and cannot incorporate elements of change in their design or implementation run the very great risk of not meeting their end objectives.

Operationalizing the Concept: What Does Adaptive Policy and Policy-Making Look like

So there is a need for policies to be 'adaptive' under conditions of change (Swanson et al 2010). But how this is to be accomplished and what does an adaptive policy look like?

While the concept of designing policies to be robust or to function effectively under a set of plausible futures, and to be adaptive or flexible with changing conditions is considered desirable in principle, there are many challenges in operationalizing such adaptive policies. Drawing a parallel between evolutionary biology and policies for sustainable development (both operating under conditions of change) Rammel and van der Bergh (2003) argue that "every successful adaptation is only a temporary 'solution'" to changing conditions and that diversity of adaptation options and flexibility to deploy these options can contribute to long-term stability.[7]

Swanson and Bhadwal (2009) suggest seven tools that can help policies to deal effectively with anticipated and unanticipated conditions. This includes:

- **Integrated and forward-looking analysis** involves identifying key factors that affect policy performance and developing scenarios depicting the likely ways in which these factors may evolve in the future. This tool can help develop indicators that can further trigger necessary policy adjustments in response to changes in these factors.

- **Multi-stakeholder deliberation** refers to a collaborative effort by multiple actors to assess policy issues and plausible solutions, prior to taking a decision and afterwards.

- **Automatic policy adjustment:** Anticipated variability in socio-economic and ecologic conditions under which a policy must operate can help fix certain 'signposts' that can be monitored to help stimulate policy adjustments.

- **Enabling self-organization** and social networks ensures that the policies upkeep existing social capital and facilitate social networking, learning and sharing of good practices to support the ability of actors to effectively respond to unanticipated future conditions.

- **Decentralization of decision-making** empowers the lowest level of governance for decision-making and thus multiplies oversight bodies and monitors.

- **Promoting Variation:** envisages creating a variety of policy responses or a policy mix in response to the same policy issue in order to increase the chances of achieving effective outcomes under uncertainty.

- **Formal policy review and continuous learning:** refers to a regular review process put in place and conducted even when the policy is functioning well.

Adaptive policies can be passive: operating on available 'best' scientific information till new knowledge comes up; or active: consciously experimenting with policy alternatives to identify better strategies as new conditions emerge (Walter, 1992). Considering adaption as a process in case errors in policy design are discovered during the policy implementation stage, it is the political actors who are essentially entrusted with policy 'correction'. Here, the political actors operate as "continuous policy-fixers" (Ingraham, 1987) and the functions of policymakers can be seen to oscillate between that of a policy 'architect', 'facilitator' and 'learner' in the policy process to appropriately 'adjust' the policies in response to changing conditions over time (Swanson and Bhadwal, 2009). Evaluation findings can refine or reshape the goals, and these might only have limited semblance to the original policy goals and objectives.[8]

Conclusion: Overcoming Failure Through Adaptive Policies

This paper provides a discussion the implications of uncertainty for policy designs and designers. It distinguishes between uncertainty and ambiguity and the different levels of uncertainty that flow from these two different aspects of the issue. The possibility of designing and enacting policies that are able to adapt to a range of anticipated and unanticipated conditions has received much attention in the past decade as a useful proposition to avoid policy failure under condition of 'deep uncertainty'.

First and foremost, the concept of adaptive policies has introduced the notion of planning for 'alternate futures' which marks a deviation from the traditional static policy

planning. The common objective of all such approaches is to avoid policy failure and aid policies to continue functioning effectively in achieving their objectives over the long-term. By deploying various approaches suggested for dealing with static and dynamic futures policymakers accept the "irreducible character" of future uncertainties (Walker et al, 2013) and the inevitable failure of static policies in a dynamic environment.

This is by no means an automatic or easy process, however. For long-term policies that address complex and dynamic policy problems there is a need for constant monitoring and evaluation to ascertain if the policies are still continuing to meet their intended goals and objectives (Ramjerdi and Fearnley, 2013). In practice, adaptive policies are those which allow for the integration of new knowledge to adapt policies and prepare institutions for long-term changes through continuous anticipation, evaluation and learning' (Volkery and Ribiero 2009). Thus learning is a key feature of adaptive policymaking but one which faces many challenges and limitations. Policymakers operate across a range of uncertainties and addressing deep uncertainty may not always be an immediate priority in terms of undertaking action. There are also challenges in communication of uncertainty for policy design (Da Costa et al, 2008) and challenges in terms of the availability of resources needed to conduct relevant analysis and justify the need to deploy additional resources to plan for 'unknown unknowns'. In many developing or least developed country contexts where resources and institutional capacities maybe already limited and often earmarked for specific activities this is an especially vexing problem which must be overcome (Bisaro 2010).

Endnotes

[1] A policy model may also contain a variety of other types of quantities playing different roles within the analysis, including constants for e.g. fundamental physical constants), decision variables over which decision-makers exert direct control e.g. environmental standards, value parameters based on preferences of stakeholders for e.g. discount rate, index variables marking the temporal and spatial boundaries of a model, model domain parameters and variables used to rank or measure likely outcomes.

[2] Schrader et al further suggest two levels of ambiguity, where the variables are given but not their functional relationships and where the variables and their functional relationships both are unknown as Level 1 and Level 2 of ambiguity respectively.

[3] Koppenjan and Klijn (2004) similarly present a classification of uncertainty focused on the interaction among actors and knowledge (or information)-related uncertainty for solving complex policy problems. Some of these uncertainties overlap with the empirical quantities identified by Morgan and Henrion, for example decision variables and value parameters and related uncertainties, and includes:

(1) Substantive uncertainty that relates to lack of relevant information related to the nature of the complex problem, and the different interpretations of information arising from different 'frames of reference' of the social actors and

(2) Strategic uncertainty arises due to unpredictability of strategies deployed by different actors based on their perception of the problem and strategies likely to be deployed by other actors.

Institutional uncertainty arises owing to the complexity of interaction of different actors guided by institutional frameworks i.e. rules and procedures of the organizations they represent.

[4] Maxim and van der Sluijs, 2011 argue that most of these typologies are largely biased towards the 'producer' of information and ignore uncertainty related to process and communication between producer and the end-user i.e. the decision-maker. To counter this drawback they developed a 'knowledge lifecycle' to capture the different dimensions along which knowledge is produced and utilized. The knowledge lifecycle consists of framing of the problem, production and communication of knowledge relevant to the policy problem.

Other types of uncertainties relevant for policymaking can relate to 'qualification of knowledge base' which refers to the evidential support for the results, and the 'value-ladenness' of policy choices, which includes actor perspectives, the knowledge and information being utilized for decision-making, the presentation of results etc. (Mathijssen et al, 2008). In tracing how uncertainty has been considered by policy scholars moving from the modern to post-modern era in the context of policy analysis and application, Bredenhoff-Bijlsma (2010) highlights that while modernism focused on the 'positivist' notion of using objective knowledge for policy analysis, post-modernism drew a focus on "socially constructed nature of scientific knowledge" emphasizing on the role of actor interactions (an idea central to network theory). Network theory considers uncertainty to be an inherent aspect of actor interaction, owing to diverse interests, positions and preferences underlying the behavior of the actors (Koppenjan and Klijn 2004).

[5] An incomplete understanding of the system may result in solutions that are ineffective or even counter-productive to the intended policy objectives (Kwadijk et al 2010). In the specific case of strategies designed to reduce the vulnerability to climate risks, for example, policies that do not consider the existence of diversity of risks, impacts and responses in a system can end up as 'policy misfits' (Bunce et al 2010) or may become 'maladaptive' as they increase risks in the long-run (Barnett and O'Niell 2011).

[6] Adaptation Tipping Points is a static approach that helps identify the conditions and time frame beyond which current policies/plans do not continue to function effectively. Adaptation Pathways that is an extension of the Adaptation Tipping Point approach by generating an alternate route for continuation of the policy/plan in a new form to achieve the initial intended objectives. Dynamic Adaptive Policy Pathways that combines the Adaptation Pathways and Adaptive Policymaking to identify alternative options over time across a range of plausible futures (Walker et al 2013).

[7] The discussion of adaptive policies is also pertinent to issues that can face natural variations such as management of fisheries which are prone to natural cyclical patterns as well as uncertainty related to harvesting. In recent years, the idea of adaptive policies has been discussed widely in the context of decisions for long-term infrastructure planning and climate change (Buurman et al. 2009; Giordano, 2012; Gersonius et al, 2013; Ranger et al, 2013). These studies explore the impacts of climate change and long-lived infrastructure and the influence of uncertainties on infrastructure policies and plans and highlight the importance of introducing flexibility and adaptiveness from the initial stage of planning itself (Giordano, 2012). The adaptive policy approach can also be applied in case of trans-boundary air pollution, which is a complex policy issue with uncertainties related to the long range forecasting of emissions, economic costs of abatement and political concerns (Kelly and Volleburgh, 2012).

[8] Van der Pas et al (2012) draw attention to evaluation of adaptive policymaking which could differ based on the criteria for evaluation- the plan itself, the process of drafting the plan and/or the product i.e. the outcomes of the plan. They also conducted a workshop on gathering expert opinion on implementation of adaptive policies by the Dutch national government. The results indicated that using adaptive policymaking is likely to increase the chances that policies realize their intended goals in the future. The experts also brought attention to institutional challenges in actually implementing these policies, primarily owing to the increased costs and time-intensiveness of adaptive policies compared to 'traditional static approaches', making it difficult for policy practitioners to justify them in the present date, even though the benefits might offset the costs in the long-run.

The experts also cautioned against the complex nature of the adaptive policy product, which may be difficult for a policymaker to present or defend, thus making its uptake and usability rather limited as compared to conventional straightforward policy planning approaches. Additionally, changes suggested to the original policies/ plans in the process of being robust and adaptive might require the original policy design to be altered significantly in some cases, which may not be politically or socially desirable.

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